



Station Simulation

Space station active rack isolation system flies on STS-79 mission



From top to bottom, left to right, 1) From left, STS-79 Mission Specialists Jay Apt and Carl Walz and David Garman, a Boeing engineer, monitor the on-orbit laptop display during an adjustment of a specially-designed force actuator on the Active Rack Isolation System as Mike Oshima, a Boeing controls engineer, adjust the actuator so the astronauts can see the effect of misalignment. 2) From left, Boeing engineer Steve Smith and technician John Drapala perform an activation step in preparation for ground testing of ARIS. 3) In the Space Station Processing Facility at Kennedy Space Center technicians install an experiment rack in ARIS. 4) From left, Apt and Walz are trained by Oshima on activities they will perform on ARIS while in orbit.

Photos by NASA and Boeing Defense and Space Group

When *Atlantis* blasted off on its fourth rendezvous and docking with the Russian Mir Space Station Monday, a prototype International Space Station rack was on board designed to counter vibrational disturbances that could potentially damage the research results of certain delicate experiments planned on the permanent laboratory in space.

The Active Rack Isolation System, or ARIS, was designed and built by engineers from Boeing, the prime contractor for the International Space Station.

"Among the many areas of research planned on space station, investigations in fluid physics, combustion science, and materials science will be performed," said Space Station Research Manager John-David Bartoe. "We will be studying the basics of how fluids behave, flow and mix; how the combustion process takes place; and how materials can be purified or formed into alloys. These questions are hard to answer in ground-based laboratories, because gravity causes unwanted effects and disturbances which hide or mask the fundamentals. On station, because it orbits the earth as if it were in constant 'free fall,' we only sense a force equal to about one millionth of the gravity level here on Earth. Some disturbances still occur on station which must be isolated, such as the vibrations of pumps and fans, crew motion, movement of solar arrays and antennas. We must isolate these vibration disturbances from the payloads, and ARIS is the isolator that will do that job."

The ARIS isolates the research payload through a sophisticated electronic sensing and control system as well as umbilical cables and actuators, allowing the rack to float within a half-inch clearance in all directions in the space station.

"The ISS Microgravity Analysis Team showed that vibrations from on-board mechanical disturbances, such as the solar array rotary joint and thermal radiator rotatory joints, as well as crew induced vibrations would violate microgravity acceleration requirements," said Vic Cooley, lead for load dynamics and microgravity in the space station vehicle office. "The analysis showed how much vibration attenuation was needed to meet the microgravity requirements and this resulted in the principal performance requirements for all candidate isolation systems. The ISS Microgravity Analysis Team working with Boeing research engineers in Seattle identified the ARIS concept as the most effective solution for meeting the requirements."

The ARIS rack flying on the STS-79 mission resides in the Spacehab module. On the second day of the mission, the ARIS was scheduled to be activated and an extensive series of tests are to be conducted

before, during and after the shuttle docks to the Russian Mir Space Station.

To simulate the weight of future scientific payloads, five lockers within the ARIS rack on STS-79 are filled with 375 pounds of Russian food packages that will be delivered to the Mir crew during the mission. After the astronauts set up the rack, testing will be conducted by Boeing engineers at the Spacehab payload control room at JSC. Once docking is complete, the food within the rack will be unloaded and the rack will be tested again. Test data will be stored on a payload computer.

"Test data will be down-linked in real time as well as stored on a payload computer," Cooley said. "The Boeing Seattle principal investigator will have first look at the data, and ISS microgravity team members will support the experiment on the ground as well."

When unlocked for microgravity operation, the ARIS rack will float within a half-inch clearance, connected to the space station module by eight actuators and a set of utility umbilicals. The umbilicals provide power, data, fluids, gases and vacuum conditions for science payloads in the rack. The umbilicals also allow some of the module disturbances to enter the rack. The control system will use accelerometers to sense rack vibration and generate response signals to the rack actuators. Then the actuators in the ARIS rack will counter those vibrations by pushing between the rack and the space station module.

Boeing Defense and Space Group engineers began developing the ARIS rack in 1994. The ARIS flying on the STS-79 mission is a prototype system to prove its concept and design. Boeing is contracted to build nine more racks for the International Space Station, with an option for six additional racks. This special system is needed for the space station to support highly sensitive microgravity research at half its payload locations.

"There were two main challenges in developing the ARIS," said John Larson, Boeing ARIS team leader. "The first challenge was the control system itself, which must operate within tight tolerances. Another challenge was the umbilical connectors for the rack, which must be very flexible so that the control system has as little to counteract as possible."

Boeing engineers in Huntsville, Ala., designed the umbilical connections and made mechanical modifications. The rack's graphite shell also was manufactured in Huntsville. Boeing engineers in Seattle designed and built the ARIS electronics and the control system, outfitted the system, conducted testing on the ARIS rack and shipped the system to the Kennedy Space Center, for launch on the STS-79 mission. □

